Discussion: Safety in South African mines

The following contributions were received to the paper entitled 'Safety in South African mines: An analysis of accident statistics', by H.S. Eisner and J.P. Leger, which appeared in the *J. S. Afr. Inst. Min. Metall.*, vol. 88, no. 1, Jan. 1988, pp. 1–7.

Contribution by H. WAGNER*

The paper by Dr H.S. Eisner and Mr J.P. Leger is critical of the safety situation on South African mines and portrays the industry as having little concern for the health and safety of its workers. Moreover, the casual reader gains the impression of deliberate misinformation by the industry to the public concerning safety matters. Furthermore, certain socio-economic reasons are advanced for the apparent differences between the fatality and injury rates reported for coal mines in South Africa and those for the United Kingdom.

The purpose of this contribution is to comment on some of the more important points, to provide technical background for the differences in safety performance of the South African and some of the major overseas coal-mining industries, and to correct some of the misleading impressions that their paper has created. It is not the intention here to highlight the progress and the many achievements of the South African mining industry in the field of mine safety. This was done recently at a safety and health congress organized by the Mine Safety Division of the Chamber of Mines of South Africa[1].

Broadly, the paper by Dr Eisner and Mr Leger addresses three main areas:

(i) accident statistics and the basis on which accident figures are quoted,
(ii) comparisons of the South African coal-mining accident statistics with those of other coal-mining countries, particularly the United Kingdom, and
(iii) attitudes to and social aspects of accidents on South African mines.

It is on these areas that I shall concentrate.

Accident Statistics

Traditionally, accident statistics for South African mines have been quoted on the basis of the total number of persons employed by the industry and are expressed as a rate, R, which is defined as

$$R = \frac{\text{All casualties (per year)}}{\text{Total number of people in service (per year)}} \times 1000.$$

Dr Eisner and Mr Leger correctly point out that accident rates based on the number of persons at work are a better measure of the mining hazards than rates based on the number of persons employed or in service. Furthermore, they stress that the hazards associated with surface and underground work are different and that, for this reason, accident rates should be published separately for surface and underground operations. In this connection, it is appropriate to mention that, since 1911, the Chamber of Mines has published fatality rates for its gold and uranium mines separated into underground and surface operations[2]. Moreover, the fatality rates for underground and surface were calculated on the average number of persons at work during the particular period (Table I).

The existence of this information is acknowledged by Dr Eisner and Mr Leger as but a brief comment under 'reference 4' of their paper. Considering the importance they place on the differences between underground and surface accident rates, it is surprising that they chose to refer to them in small print and in a reference rather than in the main body of the paper.

It is correct that coal-mine safety statistics have not traditionally been reported separately for surface and underground. However, the Chamber of Mines in its newsletter dated April/May 1984 did publish underground, surface, and opencast fatality and injury rates for its coal mines for the period 1978 to 1984[3]. This published information was, in fact, used by the authors in compiling their Table III and Table V. So it is difficult to understand how they arrived at the statement 'We are now in a position to compare the normally published fatality rates with the true underground rates for coal mining (Table V)', which is misleading since the Chamber's figures in these tables are not the result of the authors' research. Similarly, it should be noted that the information contained in Table VI of the paper by Dr Eisner and Mr Leger was taken direct from the *Chamber of Mines Newsletter* April/May 1984. I consider it important to draw attention to these details since the impression could be created that the mining industry is withholding important safety data.

Dr Eisner and Mr Leger highlight an important issue, namely the use of safety statistics for the purpose of comparing safety standards and conditions in different mining countries. They point out some of the shortcomings of the safety statistics used in the South African mining industry. These shortcomings have been recognized by the industry, and the more recent safety statistics published by the Mine Safety Division of the Chamber of Mines of South Africa[4] are based on the annual average labour at work, and are quoted separately for underground and surface workers as well as for the total workforce. While this is an improvement over previous statistics and provides considerably more detail, it still does not allow for a meaningful comparison with safety performances in different mining countries, since the definitions according

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ISSN 0038-223X/$3.00 + 0.00. Contributions received April 1988.

TABLE 1[2]
ACCIDENTS
GOLD AND URANIUM MINES—TRANSVAAL AND ORANGE FREE STATE
COMPILED FROM GOVERNMENT SOURCES OF INFORMATION

Year	Total Deaths from Accidents		Death rate per 1 000 per annum*						
			Underground		Surface		Total		
	Whites	Non-Whites	Whites	Non-Whites	Whites	Non-Whites	Whites	Non-Whites	‡Whites and Non-Whites
1911	92	814	7,05	5,45	0,79	1,60	3,57	4,02	—
1912	54	805	3,78	5,06	0,72	1,65	2,17	3,91	—
1913	65	668	5,59	4,76	0,68	1,62	3,02	3,74	—
1914	66	571	5,41	4,06	0,75	1,05	3,00	3,17	—
1915	73	632	5,67	3,80	0,75	1,20	3,20	3,07	—
1916	62	664	3,94	3,82	1,52	1,00	2,69	3,09	—
1917	68	492	5,35	3,18	0,57	0,83	2,94	2,55	—
1918	65	457	5,18	2,96	0,66	1,18	2,78	2,43	—
1919	30	459	2,40	3,22	0,28	0,79	1,26	2,56	—
1920	36	458	2,97	3,06	0,47	1,04	1,58	2,48	—
1921	39	406	3,36	2,84	0,61	0,71	1,81	2,24	—
†1922	22	322	2,72	2,64	0,66	0,81	1,50	1,88	—
1923	37	485	3,78	3,14	0,66	0,92	1,99	2,55	—
1924	28	511	2,54	3,32	0,64	0,89	1,44	2,67	—
1925	33	450	3,01	3,03	0,62	0,69	1,63	2,39	—
1926	35	440	3,57	2,89	0,21	0,52	1,69	2,26	—
1927	50	558	4,64	3,45	0,41	1,04	2,31	2,79	—
1928	34	483	2,47	2,74	0,81	1,21	1,51	2,32	—
1929	35	553	2,94	3,29	0,31	1,08	1,54	2,70	—
1930	30	554	2,35	3,24	0,42	0,69	1,31	2,60	—
1931	43	523	3,08	2,92	0,81	0,65	1,83	2,36	—
1932	33	543	2,68	2,91	0,10	0,61	1,36	2,37	—
1933	56	563	3,61	2,83	0,82	0,67	2,12	2,31	—
1934	57	553	3,42	2,50	0,55	0,80	1,89	2,05	—
1935	49	658	2,58	2,78	0,42	0,59	1,42	2,20	—
1936	60	700	2,65	2,71	0,72	0,66	1,59	2,16	—
1937	49	723	2,15	2,78	0,37	0,61	1,21	2,20	—
1938	63	667	2,38	2,38	0,71	0,80	1,46	1,94	—
1939	50	636	2,04	2,26	0,17	0,68	1,10	1,83	1,79
1940	47	662	1,81	2,08	0,35	0,80	1,04	1,74	1,70
1941	50	642	2,02	1,96	0,34	0,65	1,14	1,62	1,61
1942	40	567	1,68	1,79	0,33	0,61	0,93	1,47	1,44
1943	48	493	2,28	1,89	0,34	0,48	1,18	1,48	1,48
1944	33	475	1,75	1,88	0,17	0,48	0,84	1,48	1,43
1945	28	495	1,33	1,82	0,35	0,69	0,73	1,59	1,43
1946	37	522	1,76	2,01	0,28	0,55	0,88	1,59	1,56
1947	30	451	1,50	1,77	0,22	0,60	0,74	1,42	1,36
1948	35	457	1,59	1,98	0,40	0,46	0,85	1,52	1,47
1949	36	501	1,74	2,04	0,27	0,49	1,87	1,59	1,53
1950	55	499	2,61	1,94	0,19	0,55	1,21	1,52	1,52
1951	40	521	1,93	2,06	0,09	0,66	0,86	1.61	1,54
1952	47	558	1,84	2,24	0,51	0,66	1,01	1,72	1,69
1953	46	547	1,55	2,43	0,76	0,61	0,94	1,77	1,70
1954	44	587	1,89	2,27	0,33	0,84	0,90	1,80	1,67
1955	39	542	1,58	2,01	0,27	0,70	0,78	1,61	1,49
1956	49	612	2,15	2,20	0,13	0,64	0,96	1,73	1,65
1957	38	561	1,46	2,05	0,33	0,49	0,76	1,59	1,50
1958	45	570	1,75	1,96	0,34	0,63	0,92	1,59	1,53
1959	51	612	2,13	1,90	0,15	0,61	1,02	1,54	1,47
1960	38	627	1,44	1,96	0,22	0,47	0,74	1,55	1,45
1961	32	596	0,95	1,76	0,44	0,53	0,63	1,43	1,29
1962	46	567	1,88	1,64	0,05	0,69	0,92	1,39	1,35
1963	39	589	1,58	1,85	0,09	0,42	0,80	1,49	1,43
1964	31	526	1,19	1,65	0,21	0,33	0,66	1,33	1,27
1965	32	607	1,27	1,93	0,22	0,41	0,71	1,59	1,48
1966	34	561	1,43	1,83	0,17	0,31	0,77	1,47	1,41
1967	33	581	1,52	1,81	0,06	0,86	0,77	1,56	1,50
1968	18	491	0,64	1,59	0,33	0,38	0,44	1,30	1,20
1969	38	591	1,69	1,95	0,27	0,39	0,94	1,60	1,55
1970	27	497	1,28	1,59	0,14	0,27	0,69	1,29	1,23
1971	21	525	1,00	1,67	0,14	0,30	0,55	1,36	1,30
1972	26	485	1,05	1,59	0,45	0,30	0,69	1,29	1,23
1973	23	516	1,05	1,57	0,22	0,44	0,61	1,31	1,25
1974	13	476	0,53	1,61	0,22	0,30	0,35	1,30	1,22
1975	24	474	1,13	1,76	0,22	0,33	0,64	1,39	1,33
1976	30	527	1,40	1,84	0,29	0,43	0,78	1,45	1,38
1977	30	564	1,44	1,89	0,22	0,38	0,77	1,46	1,41
1978	23	631	1,17	2,00	0,07	0,35	0,70	1,65	1,48
1979	21	542	0,94	1,63	0,13	0,37	0,60	1,36	1,25
1980	34	599	1,33	1,73	0,40	0,33	0,84	1,44	1,32
1981	19	589	0,74	1,66	0,18	0,42	0,42	1,34	1,26
1982	27	579	1,00	1,70	0,29	0,30	0,56	1,33	1,25
1983	29	603	1,14	1,74	0,18	0,24	0,60	1,35	1,30
1984	22	578	0,69	1,62	0,35	0,28	0,45	1,25	1,18

*Note: The death rates for "underground" and "surface" are calculated on the average number of persons at work during the particular period. The "total" rates however are calculated on the average number of persons in service during the period.
†During the strike period from January to March, 1922, the active labour force, Whites and Non-Whites was much below normal.
‡Figures in this column relate only to gold mines, members of the Chamber of Mines.

to which safety statistics are calculated differ from one country to another (Table II).

TABLE II
DEFINITIONS OF CASUALTY RATES USED IN DIFFERENT MINING COUNTRIES

Country	Definition of rate	
EEC countries[6]	Number of casualties / Number of man-hours	× 1 000 000
Federal Republic of Germany[9]	Number of casualties / Number of man-hours	× 1 000 000
United Kingdom[5]	Number of casualties / Number of man-shifts	× 100 000
USA[8]	Number of casualties / Number of man-hours	× 200 000
Republic of South Africa	Number of casualties (per year) / Number of persons at work (per year)	× 1000

In the case of casualty rates based on manhours worked, it is a simple matter of comparing like with like, although even in this case clarification has to be obtained as to whether the manhours worked include overtime or have been derived from the normal working hours. Furthermore, in some countries the working time is measured from the time the worker goes underground to the time he returns to surface, while in other countries it may include the time taken for changing. In the case of the UK, where the casualty rate published by the Health and Safety Executive[5] is based on the number of manshifts worked, it is essential to know the shift time before one can make a realistic comparison with countries whose casualty rates are based on manhours worked. The South African context is further complicated by the fact that both the number of shifts worked per year and the duration of the shifts have to be known for a meaningful international comparison to be made.

Before leaving the subject of safety statistics, it is important that we address the question of injury rates. It should be noted that different definitions for reportable accidents are in use in different countries. This makes a comparison of injury rates virtually impossible. For example, in the USA accidents are separated into occurrences resulting in death, non-fatal occurrences with working days lost, and occurrences with no working days lost. In the Federal Republic of Germany, accidents are separated into occurrences resulting in death, occurrences resulting in absence from work from 4 days to 4 weeks, 4 weeks to 8 weeks, and more than 8 weeks. The accident figures published by the Safety and Health Commission for the Mining and other Extractive Industries of the European Communities[6] distinguish between fatal accidents, and accidents at work resulting in absence from work of between 4 and 20 days, of more than 20 days, and of more than 56 days. In terms of the South African Mines and Works Act and Regulations[7], an accident becomes reportable whenever it results in

(a) the death of any person, or
(b) an injury to any person likely to be fatal, or
(c) unconsciousness from heatstroke, heat exhaustion, electric shock, or the inhalation of fumes or poisonous gas, or any incapacitation normally requiring treatment in a decompression chamber, or
(d) incapacitation from heatstroke, heat exhaustion, electric shock, or the inhalation of fumes or poisonous gas that will prevent the affected person from resuming his normal or similar occupation within 48 hours, or
(e) an injury that either incapacitates the injured person from performing his normal or similar occupation for a period totalling 14 days or more, or that causes the injured person to suffer the loss of a limb, or part of a limb, or sustain a permanent disability.

From this detailed description of accident reporting in different countries, it becomes obvious that comparisons are not only extremely difficult but virtually meaningless. Furthermore, the authors' emphasis on the 14-day threshold for reportable accidents in South African mines is misplaced as indicated above.

Finally, it has been shown historically that single large accidents can greatly distort safety trends, and that comparisons of the safety performances of different mining countries and industries should be made on the basis of long-term trends to assess whether real progress in improving mine safety is being made. Fig. 1 shows the long-term trend for the South African coal-mining industry. The graph is based on the average number of persons in service and includes surface and underground workers. The data were extracted from the annual reports of the Government Mining Engineer. Two important features emerge: firstly, on a long-term basis there is a general decrease in the fatality rate and, secondly, single large accidents greatly distort this trend. Surface and underground fatality rates for Chamber of Mines collieries are available from 1978: only part of this information i.e. up to 1983, is included in Table III of Dr Eisner and Mr Leger's paper. My Fig. 2 gives the most up-to-date information, and shows how single large accidents can distort an otherwise encouraging trend.

Thus, the conclusion reached by Dr Eiser and Mr Leger that 'the South African coal mining fatality rate is, on average, eight times that of the UK, four times that of all EEL coal-mining countries taken together, and even double that of the USA' is valid only for the period examined by the authors. There was in fact a significant improvement in underground fatality rates on Chamber collieries during the period 1984 to 1986; however, this trend was reversed in 1987, when an underground explosion resulted in a substantial loss of life.

Comparison of Coal-mine Statistics

Dr Eisner and Mr Leger correctly point out that a comparison of mine safety statistics in different countries is extremely difficult. One reason for this has already been discussed, namely the different bases on which safety statistics are calculated. Added to this are more fundamental difficulties that arise from differences in the nature of the mineral deposits that are being exploited, the mining technology and labour employed, and the general state of development of the mining industries in the countries that are being compared—aspects that were largely ignored by the authors concerned.

Since conditions in deep South African gold mines are unique, Dr Eisner and Mr Leger decided to confine much

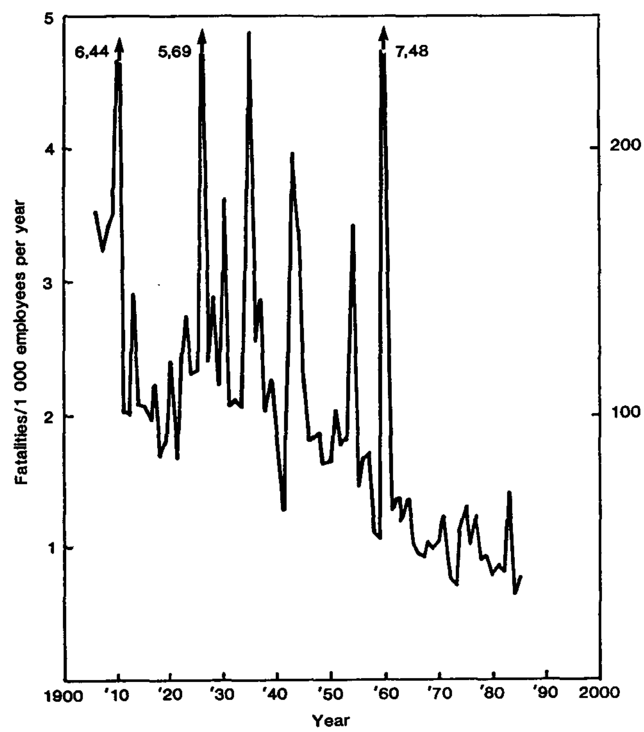

Fig. 1—Annual fatality rates on South African coal mines 1906–1985[10]

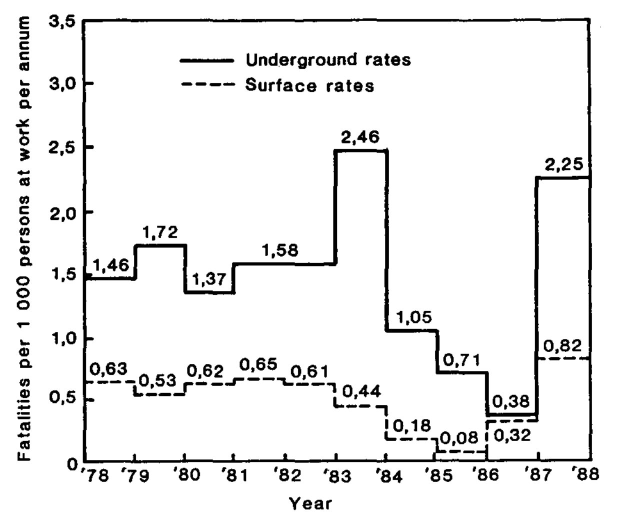

Fig. 2—Underground and surface fatality rates on coal mines belonging to the Chamber of Mines of South Africa (1978-1987)

of their study to safety on coal mines. They acknowledge that, owing to the shallowness of the coal seams, coal mining in South Africa is a mixture of bord-and-pillar mining and longwall mining and, as such, resembles coal mining in the USA rather than coal mining in Europe, where some form of longwall mining is practised. Nevertheless, most of their comparisons of accident statistics are made with respect to UK coal mines, and only a brief comparison is made of South African underground fatality rates with those in US underground coal mines.

The decision to compare South African coal-mine accidents with those in UK coal mines is therefore difficult to understand. Furthermore, it must be stressed that the differences between these two coal-mining countries are more fundamental than indicated by the authors. First, mechanized longwall mining is employed almost exclusively in UK underground coal mines. With this method of mining, roadways are supported by steel arches, and the face area, where the coal seam is extracted, it supported by hydraulically-powered self-advancing roof supports. Mining operations are confined to the development of a limited number of roadways and the actual longwall faces. As such, mining is far more concentrated than is the case in bord-and-pillar mining or pillar extraction. The supervision of mining operations is more easily achieved in longwall mining and, because of the much simpler mining layouts, ventilation of the underground workings and control of methane is more readily achieved, than in mines employing bord-and-pillar or pillar-extraction methods.

These differences become apparent when the major causes of fatal accidents in underground coal mines are compared for a number of mining countries employing different coal-mining methods (Table III). In the compilation of this tabulation the format used by the Safety and Health Commission for the Mining and other Extractive Industries of the European Communities was used[6]. Accident data from underground collieries in the USA[8] and South Africa[4] were regrouped to meet that format. To permit a comparison between the different countries, fatal accidents under the various causes are expressed as a percentage of the total fatal underground accidents. In order to make the comparisons more meaningful, a period of three to four years is considered, dependent on the availability of data.

Several important features emerge. Firstly, individual accident profiles of the European coal-mining countries

TABLE III

MAJOR CAUSES OF FATAL ACCIDENTS* ON UNDERGROUND COAL MINES IN DIFFERENT COUNTRIES

Cause	Country				
	FRG 1980	UK 1981	EEC 1982	USA 1982–84	SA 1983
Falls of ground	23,9*	22	27,1	43,6	29,1
Haulage and transport	33,3	64	38,3	18,2	22,6
Movement of personnel	14,5	5,5	12,3	2,4	3,1
Machinery	7,7	2,7	7,4	5,2	6,5
Falling objects	8,5	2,7	6,1	2,4	4,4
Explosives	1,2	–	–	1,5	1,6
Explosions of firedamp/ coaldust	1,6	–	–	7,2	24,5
Sudden outburst of fire-damp	–	–	2,5	–	–
Underground combustion and fires	–	–	–	10,8	–
Inrushes of water	–	–	–	–	–
Electricity	–	–	1,2	7,2	2,3
Other causes	6,8	2,7	5,0	1,5	5,2

* All figures expressed as a percentage of total fatal underground accidents

that employ predominantly longwall-mining methods differ from those of the USA and South Africa, where a mixture of longwall mining, bord-and-pillar mining, and pillar extraction is used. Secondly, fatal accidents caused by falls of ground are a more serious problem in countries employing bord-and-pillar and pillar-extraction methods of mining. Thirdly, the control of fire and explosion hazards appears to be more readily achieved in countries employing the longwall method of mining. From this comparison it follows that it would have been more appropriate for Dr Eisner and Mr Leger to have compared safety in South African coal mines with that of countries employing a similar mix of mining methods, such as the USA, or even Australia and Canada.

The second major difference between the coal industries of South Africa and the UK concerns the nature of the workforce. Coal mining in the UK has a long family tradition, and there are numerous instances where families have been involved in coal mining over many generations. Furthermore, the workforce on European and UK collieries is mainly a first-world workforce. In contrast, the coal-mining industry in South Africa has a relatively short history, is largely free from tradition, and employs a predominantly third-world workforce. In view of the well-established human element in accidents, the significant differences in the nature of the workforces employed on UK and South African collieries cannot be ignored when accident statistics are being compared. From this point of view, it would have been more appropriate and meaningful to have compared the safety performance of South African collieries with those of India and China.

The third major difference between the South African coal industry and that of the UK is that the former is expanding while the latter is shrinking. Fig. 3 compares tons of coal produced and number of persons employed in the two countries. It can be seen that, during the period 1966 to 1985, UK coal production decreased from 168,8 Mt to 88,2 Mt, while the total workforce employed by UK collieries shrank from 447 700 persons to 154 600. During the same period, South African coal production increased from 54,6 Mt in 1970 to 173,1 Mt in 1985, while the total workforce increased from 75 700 to 119 300. In examining the South African coal-production figures, it should be noted that the opencast proportion of coal production increased from less than 10 Mt in the early 1970s to 63 Mt in 1985.

The reduction in coal production in the UK was brought about largely by the closure of collieries with difficult working conditions and high costs. It is an established fact that such a process of negative rationalization has beneficial effects on safety. On the other hand, the South African underground coal production more than doubled during the period 1970 to 1985. This was achieved largely through increasing production capacities on existing collieries and through bringing new collieries into production. It is well recognized that good safety performance is more difficult to achieve during an expansionary phase. The reasons for this are that the labour force is new and generally inexperienced, mining conditions in new areas are largely unknown, and, there is a higher proportion of more difficult mining operations such as shaft sinking.

Thus, because of the fundamental differences that exist between the two coal-mining industries, it is difficult to recognize any useful purpose in the comparison of safety statistics. A far more meaningful investigation would have been to identify the causes for the substantial differences in safety performances of collieries in the UK and the Federal Republic of Germany. At least such a comparison would not have been clouded by differences in the mining methods, labour force, and development stages of those industries. One cannot therefore escape

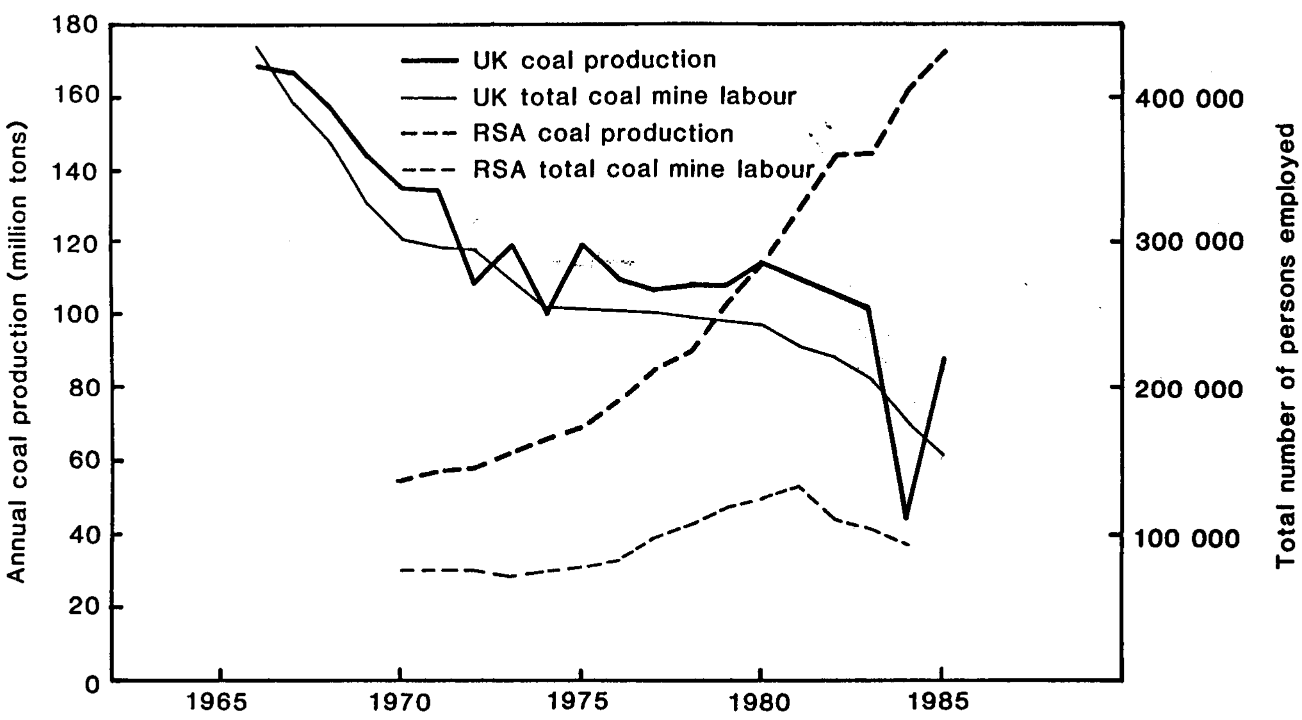

Fig. 3—Annual production and employment figures for the South African and UK coal industries (1966–1985)

the conclusion that the purpose of the comparison of the safety satistics of collieries in the UK and South Africa is other than technical.

Regarding the comparison of reportable injury rates on South African coal mines with those of the UK, Dr Eisner and Mr Leger conclude that 'Since the South African underground fatality rate is so much higher than in the UK, it is likely, though of course not certain, that the South African injury rates, which are a good deal lower than the corresponding UK rates, are affected by factors other than safety'. They continue, 'No doubt so are the UK rates, but the South African (14+ days) threshold provides much more scope for this than the UK (4+ days) threshold; it is much less demanding to shorten a 14-day convalescence period by one day to 13 days (when an accident becomes non-reportable) than to do the same with a 4-day period'. Since data on the duration of the injury times of mineworkers are not readily available, the authors made use of information published by the Workmens' Compensation Act Statistics 1982, which covers mineworkers and some Exempted Municipalities and Mutual Associations. In Fig. 1 of their paper they noted 'that the large majority of accidents (some 82 per cent) led to periods of absence of less than 14 days, and that an abrupt fall in accident frequency occurs on or about the 14-day threshold. An abrupt rise is also noticeable for the (4+ days) category of accidents, i.e. the compensatable category. Both are evidence of distortion'. In coming to this latter conclusion, the authors failed to realize that the class intervals in Fig. 1 of their paper are not constant. In particular, the class interval increases after six days absence from a three-day interval to a seven-day interval. Consequently, the profile of their Fig. 1 is highly misleading since the number of accidents recorded for the period 7–13 days should also have been distributed over at least two class intervals. Moreover, the 28–56 peak is again caused by a sudden change in class interval from a 7-day to a 28-day interval. Thus, on the information given, there is no statistical evidence for their statement that 'an abrupt fall in accident frequency occurs on about the 14-day threshold'.

In comparing 'compensatable accidents' in all member mines of the Chamber, i.e. accidents (surface plus underground) that result in a loss of 4 or more shifts, with the UK (4+ days) rate, the authors note that 'For the three-year period 1980–1982, the South African rate lies between 75 and 60, and is thus very much lower than the relevant UK coal-mine rate, which lies between 151 and 113. Bearing in mind that, for these years, the injury rate (14+) in all COM mines was about 2 to 3 times the COM coal-mine rate[4], it is noteworthy that the (4+ days) injury rate of UK coal mines should be between 4 and 6 times as high as the COM compensatable (all mines) injury rate, especially when the UK fatality rate is so much lower than the COM rate. Such discrepancies in injury rates between the two countries could arise for the following reasons:

(i) SA has lower frequency and/or severity rates than the UK or
(ii) for accidents of similar severity, South African mineworkers lose less time from work than their UK counterparts, or
(iii) a combination of the two.'

Before commenting on these conclusions, I think it appropriate to examine the injuries published for US underground collieries[8] since, as shown earlier, US collieries are more comparable with South African collieries. Unfortunately, the official statistics[8] do not provide details of the minimum number of days lost since the non-fatal injuries that resulted in days away from work are published. For the period 1982–1984, these rates ranged from 73 to 86 occurrences per 1000 workers per year. These rates compare with the 'compensatable accident' rates published for all Chamber mines and are substantially lower than those reported for UK coal mines, particularly if the inclusion in the US figures of accidents with less than 3 days lost are taken into account. In a comparison of US injury rates with those of UK coal mines, it should be mentioned that the underground fatality rates on US collieries during the period 1982–1984 varied between 0,50 and 1,04 fatalities per 1000 underground workers per year and, as such, were very much higher than UK underground fatality rates, which varied between 0,14 and 0,21 during the period 1980–1982 (Table VIII in the paper by Dr Eisner and Mr Leger). Thus, one cannot draw conclusions about injury rates from published fatality rates. This suggests that the conclusions reached by Dr Eisner and Mr Leger are without foundation.

Social Aspects of Accidents

On several occasions the authors suggest in their paper that economic pressures and the introduction of the International Mine Safety Rating (IMSR) scheme to Chamber mines 'stimulate' mineworkers to an early return to work after an accident. There is no evidence in the paper to provide conclusive proof for this assertion. Since mineworkers on South African coal and gold mines are subjected to the same economic pressures, and since the IMSR scheme applies to both categories of mines, it could be argued that, if the reasons advanced by the authors are as powerful as they claim, then reportable injuries on gold and coal mines should tend to become very similar. However, an examination of injury rates for gold and coal mines as reflected in Table X of the paper by Dr Eisner and Mr Leger shows that the differences in gold- and coal-mine injuries persisted over a 15-year period, even though the actual numbers decreased in both industries. This suggests that there are inherent differences in mining hazards between gold and coal mines. Each mining industry has specific and sometimes unique safety hazards, and for these reasons it is futile to make direct comparisons.

Concluding Remarks

This contribution highlights the difficulties that are encountered when safety statistics are compared between different mining countries and different mining industries, and cautions against the indiscriminate use of statistics in making such comparisons. Instead, safety achievements should be measured over long time periods, and the rate of improvement should be considered as the measure of progress that is being made in improving safety. There can be no doubt that safety is and must remain the major consideration in any mining venture. Any comment that can contribute to improved safety thinking and awareness must therefore be welcomed.

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Contribution by S.A. WATTS*

Authors Eisner and Leger are to be commended on their paper, which highlights, according to their interpretation, various shortcomings of both the Chamber of Mines accident statistics and those published by the Department of Mineral and Energy Affairs.

Days Lost from Work

Although their paper contains several contentious issues, one inference made by Eisner and Leger invites specific criticism.

The authors imply that, based on Section 25.1(e) of Chapter 25 of the Mines and Works regulations, the reportable injury threshold of 14 days invites mines to encourage their workforce to return to work prior to 14 days off work, thus preventing the injury from becoming reportable. They illustrate this assumption with Fig. 1, which is reproduced here.

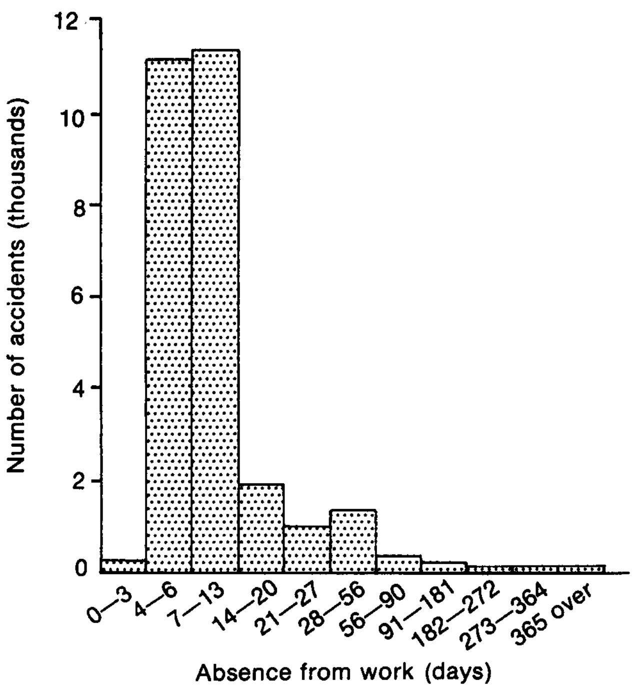

Fig. 1—Number of accidents leading to temporary disablement of Black workers: Absence from work in days (based on Workmen's Compensation Act Statistics, 1982, for the Exempted Municipalities and Mutual Associations)

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However, this histogram is misleading since the class intervals on the x-axis, i.e. absence from work (days), are not uniform. Had these data been presented using equal time intervals on the x-axis, the picture would have been very different.

Figs. 2 and 3 are used to illustrate this point. These two graphs depict 'compensable' accidents for 1987 in member mines of the Chamber, a compensable accident being an accident that results in 4 or more days lost, or 1 to 3 days lost where either permanent disability has been incurred or a claim for medical expenses (including dentures and spectacles) has been incurred.

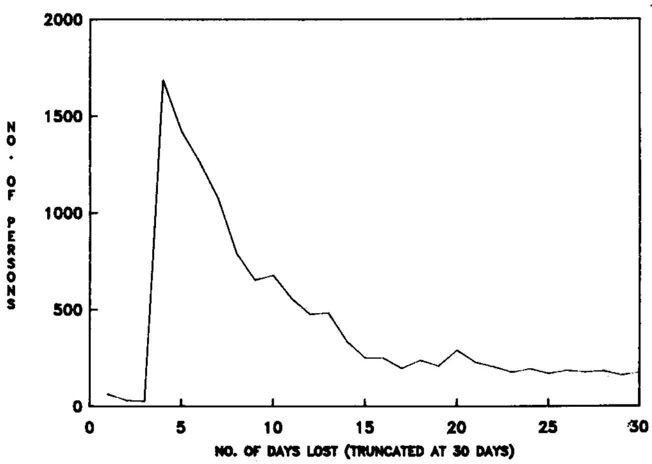


Fig. 2—Number of persons involved in compensable accidents for 1987 excluding fatalities—for gold and coal mines of the Chamber of Mines of South Africa

Fig. 2 serves to repudiate the inference by Eisner and Leger that 'an abrupt fall in accident frequency occurs on or about the 14-day threshold'. In fact, the abrupt fall in accident frequency ceases on the 9th day, and a more gradual decrease then continues until the 17th day, after which the line-chart levels out.

Fig. 3 shows *exactly the same* data as Fig. 2, but has the same unequal class intervals used by Eisner and Leger in their Fig. 1, to illustrate just how misleading a histogram with unequal class intervals can be.

Eisner and Leger point out, using Fig. 1, that 'an abrupt rise is also noticeable for the (4 + days) category' compared with the 0–3 day period. This abrupt rise is due to the fact that compensation is awarded only after 4 or more days off work, apart from those exceptions mentioned earlier.

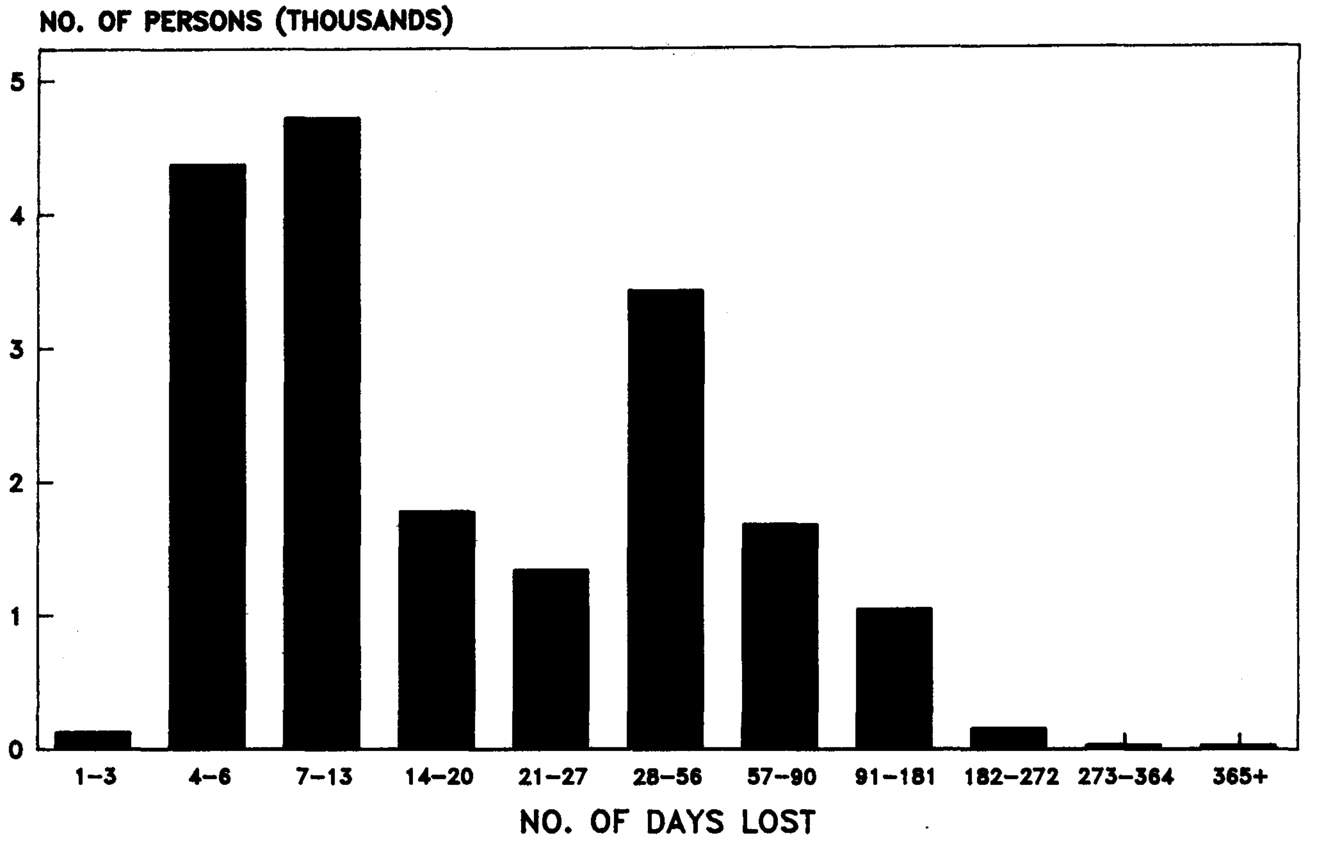


Fig. 3—Number of persons involved in compensable accidents, 1987—for gold and coal mines of the Chamber of Mines of South Africa

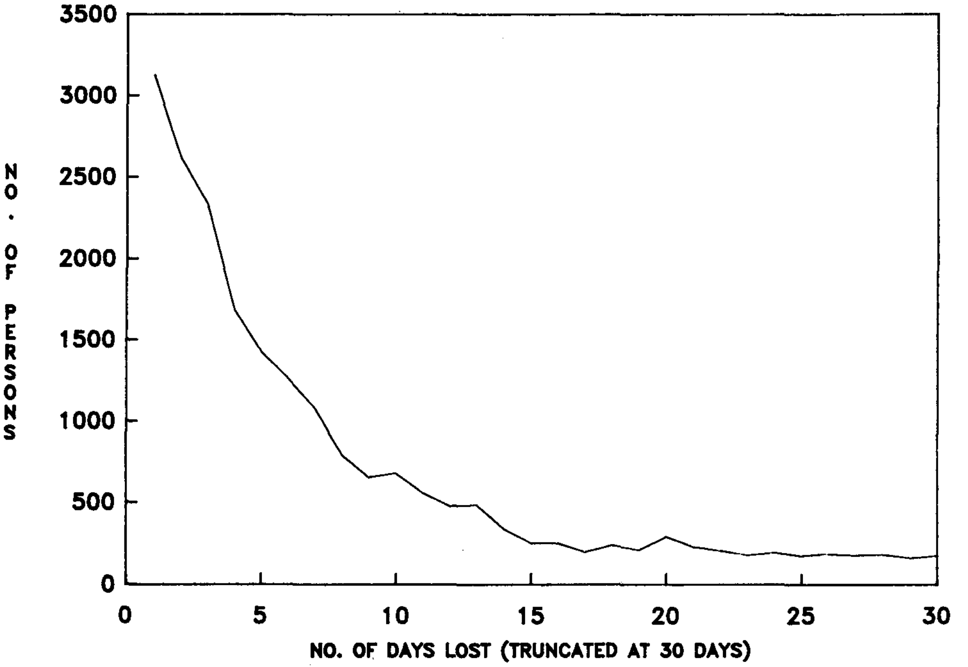


Fig. 4—Number of persons involved in all accidents resulting in one or more days lost, 1987—for gold and coal mines of the Chamber of Mines of South Africa

It should be noted that no statistics of 1-3 day accidents are required by the Workmen's Compensation Act. Hence, they are not present in the statistics used by the authors. However, the Chamber of Mines collects statistics from its member mines of *all* accidents resulting in 1 or more days lost, and it can be seen from Fig. 4, which uses preliminary 1987 data, that there is no noticeable abrupt rise for 4+ days lost time. In fact, the number of persons off work declines steadily as the number of days lost increases, as would be expected.

Conclusion

The purpose of this comment is not to decry the work done by Eisner and Leger, but to correct various misleading impressions made by the authors.

Authors' Reply

We gratefully acknowledge Dr Wagner's contribution to the discussion on our paper. For convenience, we shall use his sequence of comments in our reply. Before doing so, however, it may be useful to explain how our paper came to be written.

After the explosion at Hlobane Colliery in 1983, one of us (HSE), in February 1984, was retained by the lawyers acting for some of the dependants of the victims to advise on technical matters relating to the explosion. Although intimately familiar with the coal industry in the UK, and reasonably acquainted with those of Europe (east and west) and of the USA, he lacked any knowledge of South African mining, coal or gold, and in his first attempts to come to grips with this subject felt that it was necessary to familiarize himself with the relevant accident statistics.

He found himself confronted with extensive statistical information on accidents in South African mines, in the form of annual publications by both the Department of Mineral and Energy Affairs (DMEA) and the Chamber of Mines (COM), as well as of papers in the South African mining press. On closer study, however, two features stood out: (i) certain deficiencies and idiosyncrasies in the presentation of the figures, and (ii) undue reliance by the authors and mining officials involved in the commentaries on an apparently favourable decline in the injury (as distinct from fatality) rates in the industry. It was these findings that prompted him to begin a series of studies in which he was later joined by his co-author (J-PL).

Accident Statistics

The publication of separate underground and surface accident rates for COM coal mines in the *COM Newsletter* of April/May 1984 was the first and only publication of these data until the Death and Injury Rate Tables of 1987. The publication of these rates was directly stimulated by a statement made by one of us (HSE) at a news conference reported in the *Rand Daily Mail* (*Business Mail*) of 8th February, 1984, and *The Star* of 9th February, 1984. This is clear from the last paragraph of page 2 of the *Newsletter*: 'following a suggestion that the inclusion of opencast mining distorts the coal industry fatality rate and is misleading'. This suggestion was in fact made at the news conference as one of a number of possibilities (unjustified as it turned out because of the relatively few opencast workers) by one of us (HSE). We have at no time claimed that the figures we derived from the *Newsletter* were the result of our own research. We are indeed glad to note that, from 1987, underground coal-mining accident rates have been published, and will continue to be, by COM. Unfortunately, this publication came too late for our paper, which was submitted for publication in November 1986.

The long-term trend of a decline in fatality rates in South African coal mining from 1900 to about 1970 shown in Dr Wagner's Figure 1 does not invalidate our point that, since then, there has not been any significant improvement. Similar declines over the same period can be shown for all major mining countries. Furthermore, the figure once more presents the overall fatality rate for surface and underground workers taken together. We argued that this resulted in a misleading impression being gained, and Dr Wagner concedes that the rates should be quoted separately. Since the proportion of surface workers at work rose from 37 per cent in 1970 to 52 per cent in 1983 (the most recent figure published), a different picture would emerge if the underground rate were presented as a graph. In Fig. A we reproduce Dr Wagner's Figure 1 on which the available underground fatality rates are superimposed.

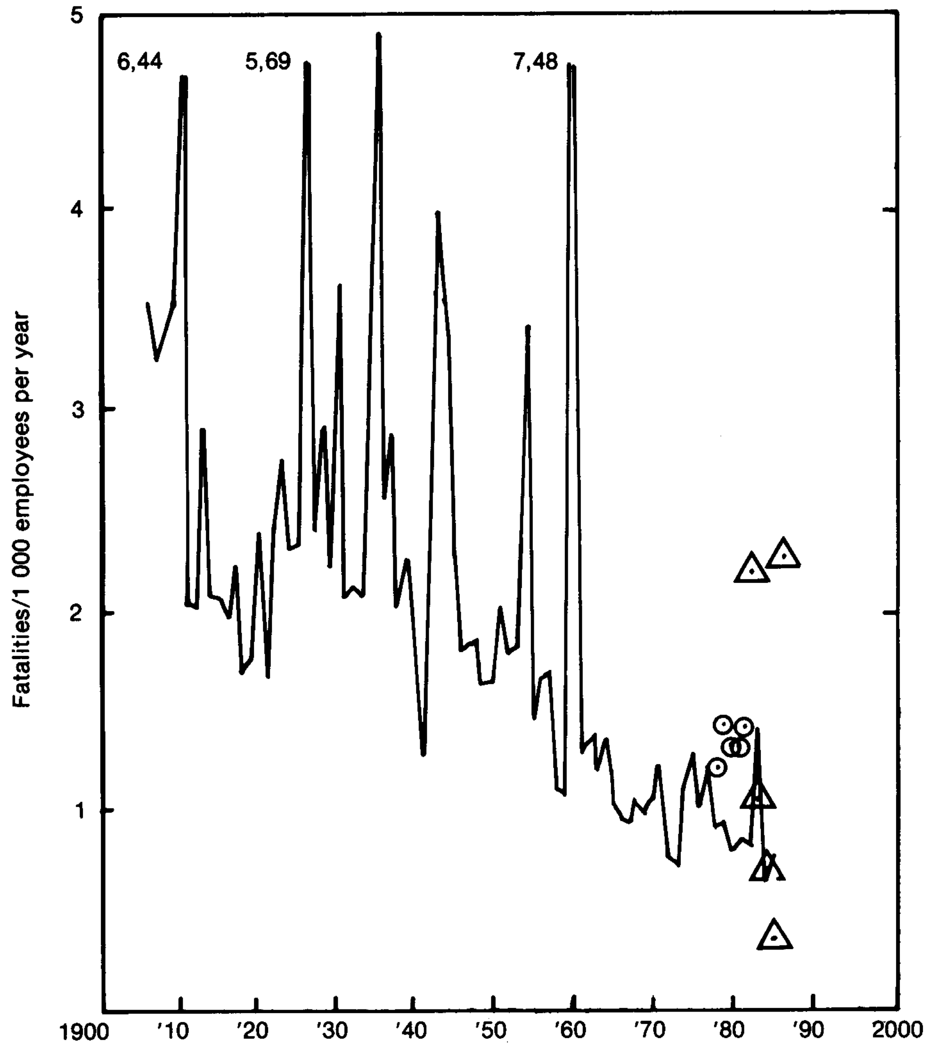
As regards the effect upon the figures of large accidents, we have dealt with this in our paper; to exclude such accidents from the count could be justified only if they did not occur so regularly. This applies even more cogently to gold mining.

Comparison with Other Countries

We have stressed the difficulty of comparing injury (as distinct from fatality) rates between countries and industries. We would not, in fact, have troubled to compare even fatality rates, had it not been that the Chamber forestalled us. Well before we arrived on the scene, the *COM Newsletter* of September/November 1983 made such comparisons between its coal industry and that of West Germany and the USA, and between its gold industry and US metal mining. Earlier still, in January 1983, speaking at Ermelo, Mr D. Rankin, then Chairman of the Chamber's collieries committee, compared the colliery fatality rate in South Africa (unfavourably) with UK and US rates (*Rand Daily Mail Business Mail*, 11th February, 1984). Statements about South African mining having set world records in safety appear in the Report of the Government Mining Engineer for 1981 and in papers by G. Relly in 1984 (*Loss Control Survey*, February, p. 3) and D.J. Miles in 1981 (*Loss Control Survey*, August, p. 19) among others. More recently the then COM President, Mr E.P. Gush, in his 1987 presidential address compared the fatality rate in South African coal mines with West German, US, and UK rates (Chamber of Mines of South Africa, *Annual Report 1986*).

Dr Wagner finds it difficult to understand how we can make comparisons between fatality rates in coal mines in countries where mining conditions, methods, traditions, and labour forces are as fundamentally different as those of the UK and RSA, and he comes to the somewhat sinister conclusion that the 'purpose of the comparison of the safety statistics of the UK and RSA collieries is other than technical'. Not so the abovementioned Mr Rankin, who believes that, 'because of the shallowness of our [South Africa's] workings and our generally more favourable working conditions, our rate should be at least as good as the British rate'.

Why indeed make such comparisons? Responsible demographers the world over compare, say, infant mortality in one country with that in another, irrespective of living conditions, traditions, economies, etc. They do so in the hope that the knowledge will help to demonstrate to the poorer performer that better results *are* achievable. Nor should we confine ourselves to a comparison of *rates*. Because of the very large number of people employed in



Notes: ⊙ Fatalities/1000 underground employees at work per year for all South African coal mines.

— Fatalities/1000 underground and surface employees in service per year for all South African coal mines.

△ Fatalities/1000 underground employees at work per year for Chamber of Mines coal mines.

Fig. A

South African mines and the often exceptionally high number of dependants attached to each, the sum total of suffering entailed in the 700 to 800 annual deaths and the 12 000 to 14 000 'reportable' injuries, most of them leading to some form of permanent disability, ensure South Africa a rather special place in the league table of occupational accidents. Compared with the UK, the population of which is roughly twice that of South Africa, such casualty figures make a still greater impact on the latter.

Dr Wagner lists a number of factors that differentiate South African coal mining from that in the UK, such as mining methods, a 'third world' labour force versus a 'first world' one, an expanding versus a contracting industry. He adduces no evidence that 'it is an established fact that such a process of negative rationalization (as exists in the UK coal-mining industry) has a beneficial effect on safety', nor that 'it is well recognized that good safety performance is more difficult to achieve during an expansionary phase'. Are accident rates higher in the new mines than in the older ones? No doubt an interesting, but hitherto unsolved, problem. We have elsewhere (South African Mine Safety and Health Congress, November 1987) suggested some rather more down-to-earth reasons for the relatively indifferent safety performance of South African mines. These include a rather poorly qualified and inexperienced bottom tier of supervisory staff (almost wholly 'first world') charged with the statutory responsibility for safety, spread much too thinly over the labour force, and a numerically small, however excellent, mines inspectorate.

Attitudes

Dr Wagner points out that we produce no evidence for our suggestion that such schemes as the International Mine Safety Rating stimulate workers after an accident to return to work earlier, and produces a tortuous argument, using the discredited reportable injury rate for gold and coal mining, to show that our surmise is wrong. We shall be dealing separately with the International Mine Safety Rating scheme in a critique that is to be published shortly in the *Journal of Occupational Accidents*. We agree, of course, that there are very large differences in the nature and size of the hazards in the two industries but, for reasons that we do not yet understand, it so happens that the underground fatality rates do not appear to differ by very much. Could it be that the people who manage and work in gold mines pay more attention to safety than those in coal mines?

All such possibilities show that the analysis of data on mining accidents is by no means an exact science, and that over-optimistic as well as over-pessimistic attitudes must be avoided at all costs. Any progress in this field must in the first place be based on the gathering and publication of plentiful and reliable statistics. Some mining countries, notably those of Eastern Europe, do the gathering but not, alas, the publishing. South Africa both gathers and publishes a profusion of such material. If we have contributed in a small way to ensuring that what *is* published accurately reflects the effects of the many mining hazards encountered, we shall be content.

Contribution by Ms S.A. Watts

Some of the points made by Ms Watts have already been answered in our comments on Dr Wagner's contribution.

We are fully aware that the number of accidents leading to absences of less than 4 days would be much greater than shown in our bar chart, and are grateful to Ms Watts for drawing attention to the specific exceptions that can make a 1-3 day accident compensable and that are clearly responsible for the relatively low count in that category of the chart.

As regards the statistical aspect of our bar chart (not a histogram), there is nothing sacrosanct about a uniform class interval in such a chart. In point of fact the class intervals used are not of our own choosing but simply reproduce those in the tables of the 1982 Workmen's Compensation Act statistics (the most recently published statistics at the time). The compilers presumably found them a convenient way of presenting their data. They can clearly not be refuted by Ms Watts' citation of a different category of accidents for a different labour force exposed to accidents in a different year. The figures provides by Ms Watts apply to both permanent *and* temporary disabilities in 1987, and only for COM gold and coal mines. Our figure referred only to temporary disabilities for 1982. If Ms Watts can produce a more detailed set of data in respect of our chart that back up her contention, we would of course accept them unhesitatingly.

Added value in the mineral industry

A morning symposium entitled 'Added Value Implementation in the Metal and Mineral Industry', and aimed at highlighting the potential for import replacement and export-related added value in the mineral and metal industry, will be held at Mintek on 30th September, 1988. The Symposium is being organized by the Technology Market Foundation (TMF) and the Council for Mineral Technology (Mintek).

The TMF has been formed with the assistance of the

Techno-Economic Society of South Africa (Tessa),
Council for Mineral Technology (Mintek),
Chamber of Mines, and
Rand Afrikaans University.

The objective of the TMF is to promote the development of added value in the mineral and metal industry through the exchange of licensing of technology and the setting up of joint ventures both in South Africa and overseas.

This will increase import replacement and export. It is believed that, by use of the joint-venture concept, the advantages of two nations can be combined and most of the negative points eliminated. In order to develop this concept, it is necessary to develop close person-to-person contact. The Foundation, during last year, brought 38 industrialists from the Far East, Europe, and South America to visit the South African Industries and Technology Fair, and to participate in a 5-day industry tour to see steel, copper, plastics, stainless-steel, and other South African industries.

It is planned to invite another 40 overseas industrialists to South Africa during the period 26th September to 8th October, 1988. This will give guests the opportunity of visiting the Electra Mining Exhibition in Johannesburg, attending the Symposium, and participating in technological tours.

The Symposium and visits will be of interest to industrialists, investors, planners, and technical support staff involved in planning in the mineral and metal industry. The opportunity to meet overseas industrialists will help to establish contact for future negotiations.

The Symposium will be a forum on added value in the mineral and metal industry. The subjects covered will include stainless steel, copper, manganese, aluminium, and alloy steels. It will also highlight the important role to be played by metal fabricators, engineering project managers, and contractors in maximizing added-value potential. Overseas market-development experts will be included in a panel discussion that will review international markets and technological trends.

Further information is available from

The Conference Liaison Officer
Mintek
Private Bag X3015
Randburg
2125 South Africa.
Tel.: (011) 793-3511
Telex: 4-24867
Facsimile: (011) 793-2413.